Ticosonde CFH at Costa Rica: A seasonal climatology of tropical UT/LS water vapor and inter-comparisons with MLS and CALIPSO

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Aura STM Sept 16, 2014

Talk topics

A. Seasonal structure at Costa Rica: T, ozone and the water vapor tape recorder

B. Intercomparison to MLS v3.3 WV

C. Relationship between sonde saturation and CALIOP cloud fraction

D. Changes of WV in the tropics UT/LS

- Comparisons of sondes to MLS at 82 hPa
- 2-km WV time series at Costa Rica

Science drivers

A. Processes controlling stratospheric water vapor: local freeze-drying, transport from remote tropical regions, in-mixing from higher latitudes

B. Continuing differences among *in situ* water vapor instruments

C. *Jensen et al.* [2013] found differing saturation regimes for low- and hi-particle density cirrus

D. Radiative forcing of UT/LS water vapor and impact in warming climate

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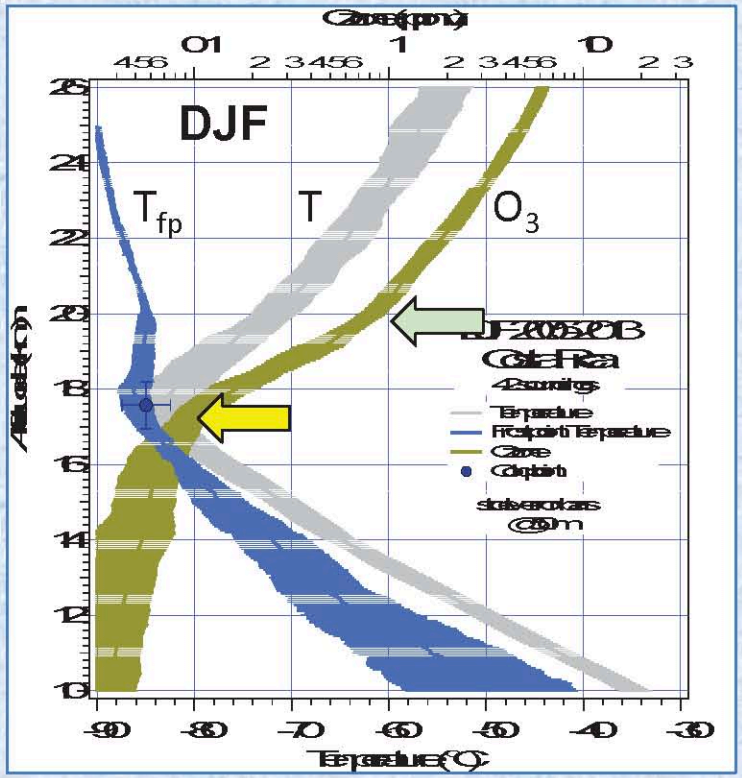
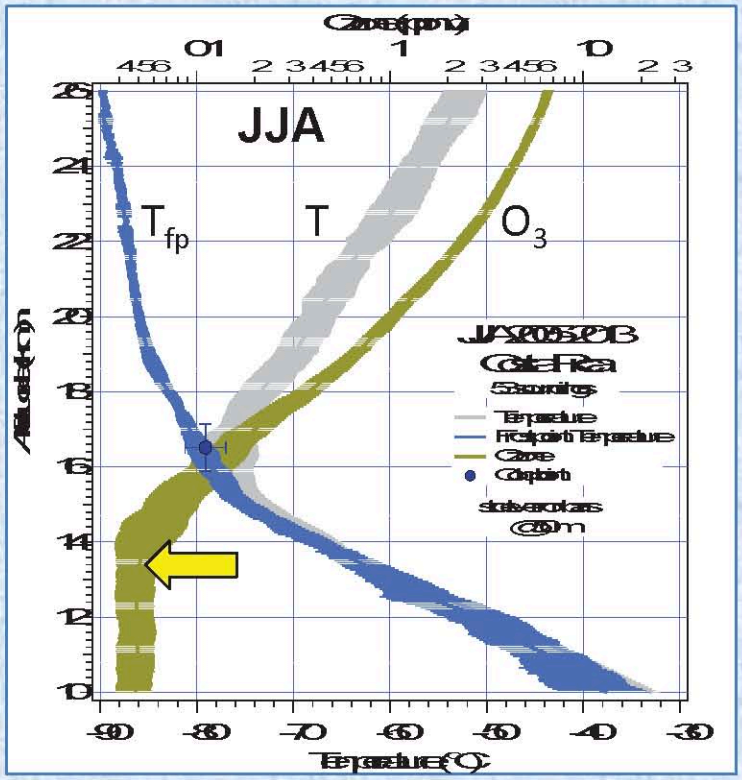
Mean Dry and Rainy Season Profiles

2005-2013

Frostpoint temperature, ambient temperature, and ozone





CPT at base of profile minimum T_{fp} /water vapor

Ozone gradient change nearly coincident with mean coldpoint

Prominent inflection in O_3 profile @ 20 km

- CPT overlain by decreasing T_{fp}/WV

Ozone gradient change well below mean coldpoint

Smooth ozone profile throughout

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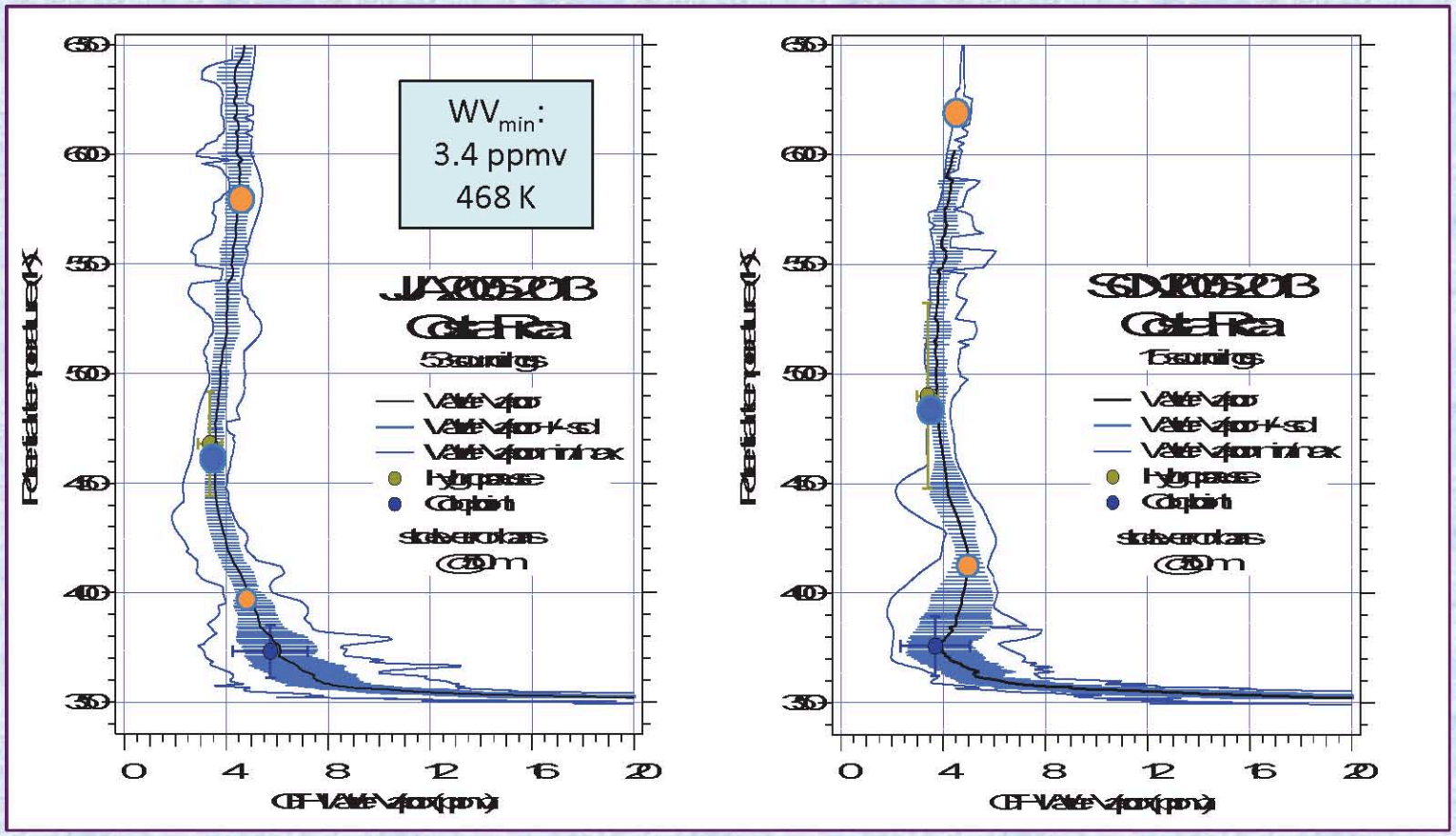
Tape recorder - I

Second half of year – JJA and SON



- 4 ppmv "hygropause" clearly visible at 468 K in JJA
- 5.5 ppmv maximum rises out of TTL in SON to 415 K

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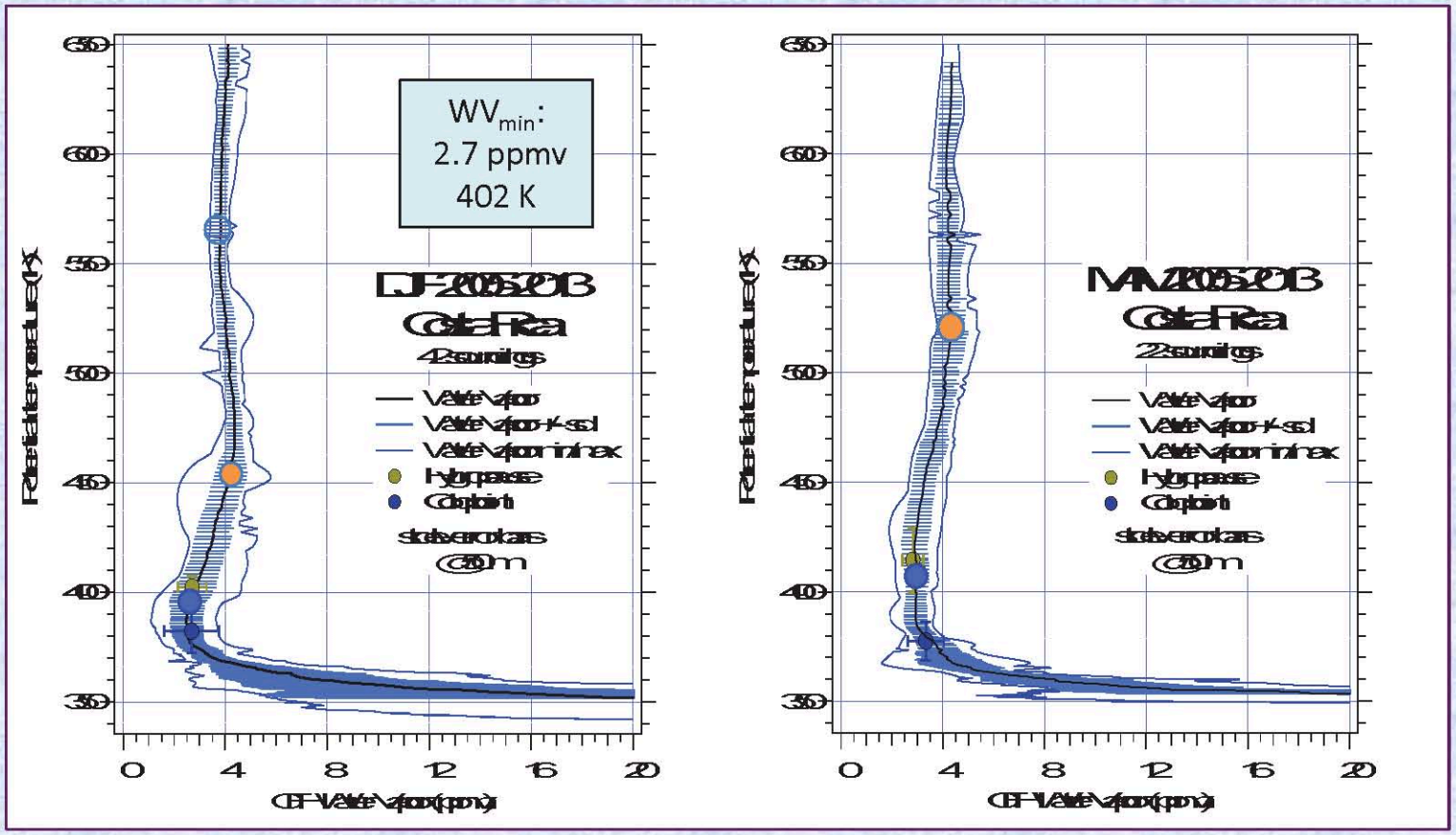
Tape recorder - II

First half of year – DJF and MAM



- Profile minimum near trop in DJF and slow movement upward through MAM
- But SON max near 420 K has moved up to 460 K by DJF and 525 K in MAM
- Weak ascent in LMS during DJF and MAM, but more rapid above 450 K

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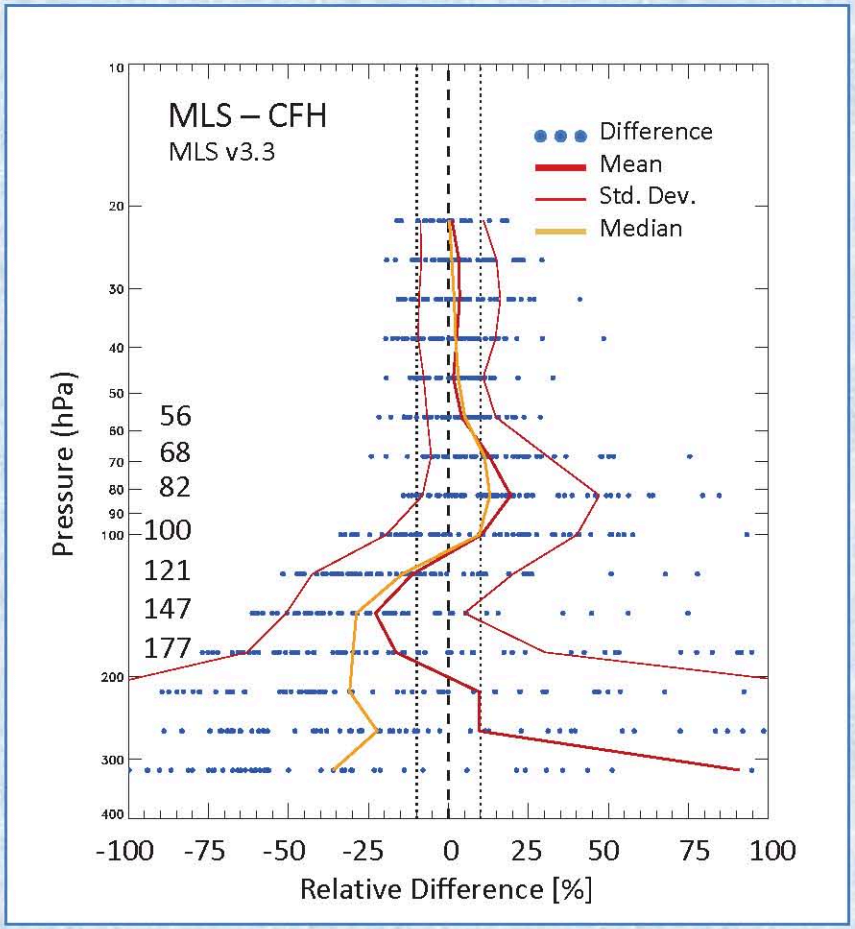
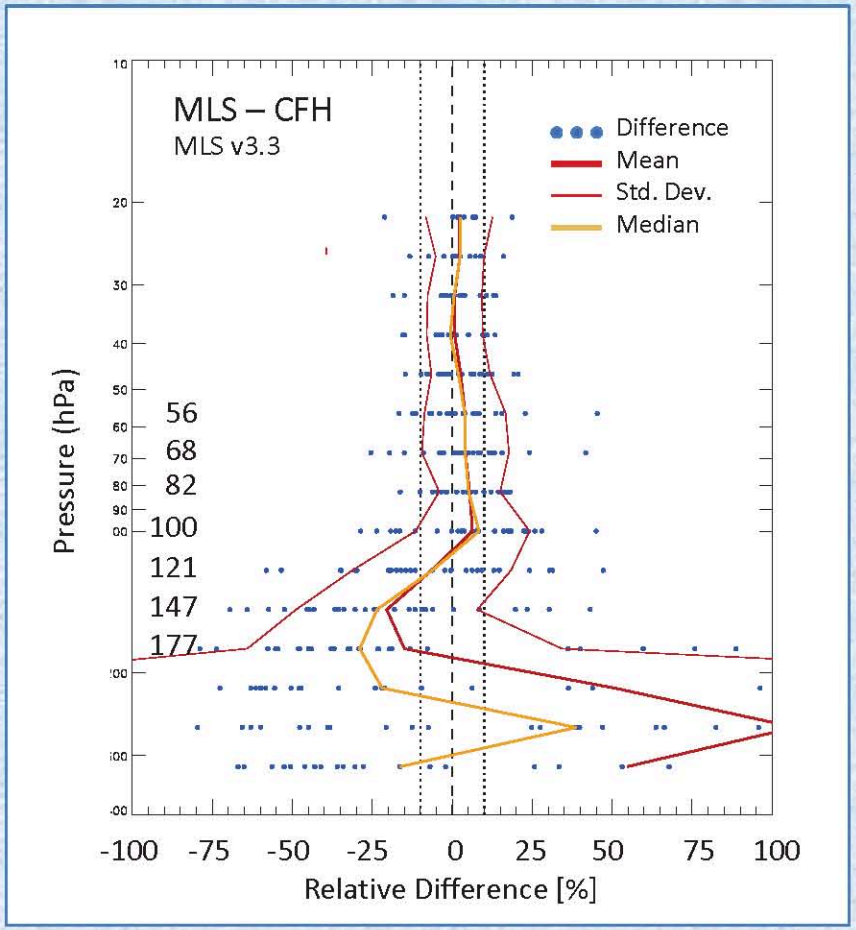
Coincidences with MLS v3.3

±3 hours, Δ ≤ 600 km





December – February

65 coincident soundings:

Costa Rica (35), Biak (19), Kototabang (4), Tarawa (4)

June – September

28 coincident soundings:

Costa Rica (22), San Cristobál (6)

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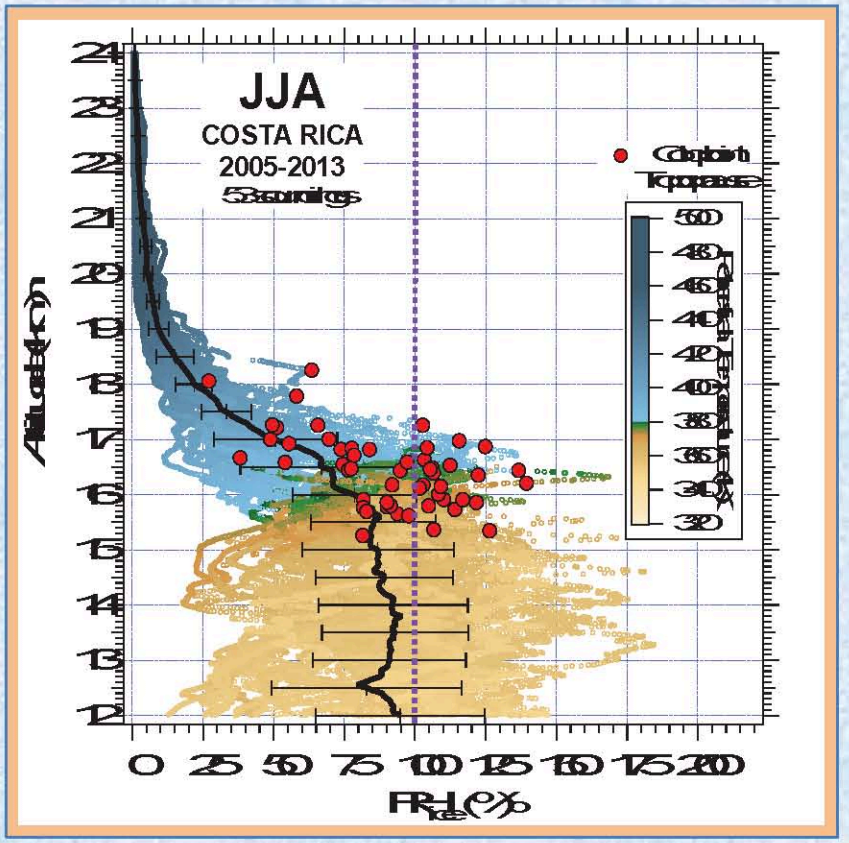
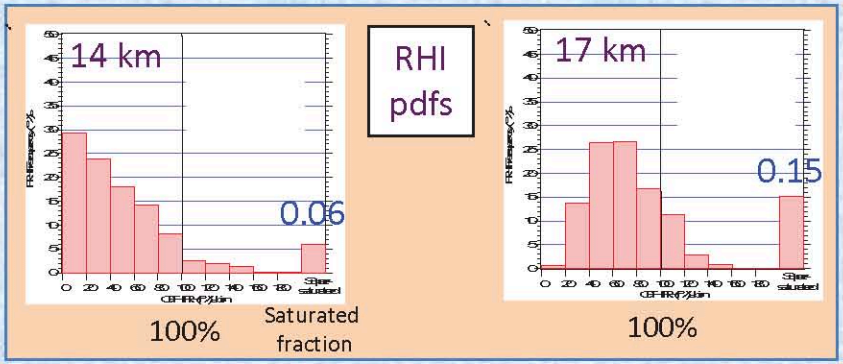
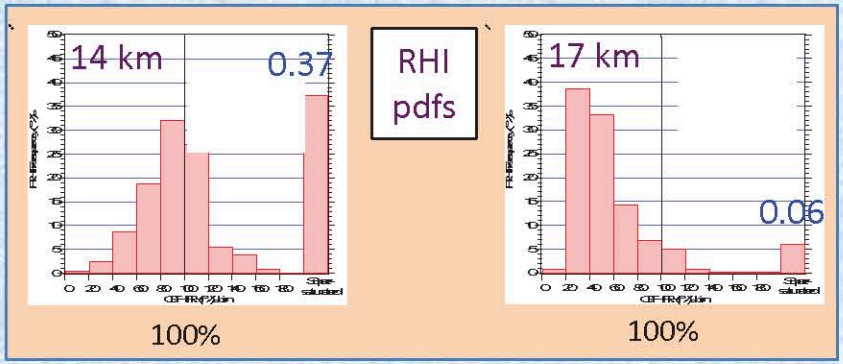
RH_{ice}: DJF vs. JJA







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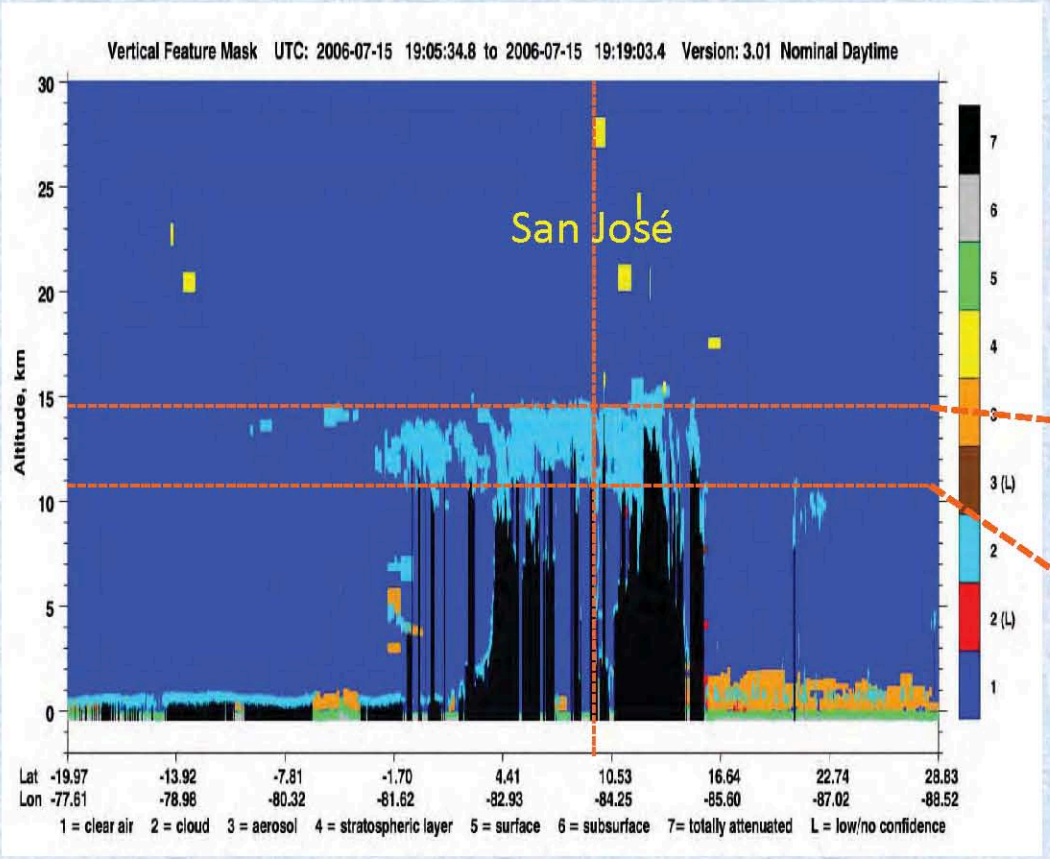
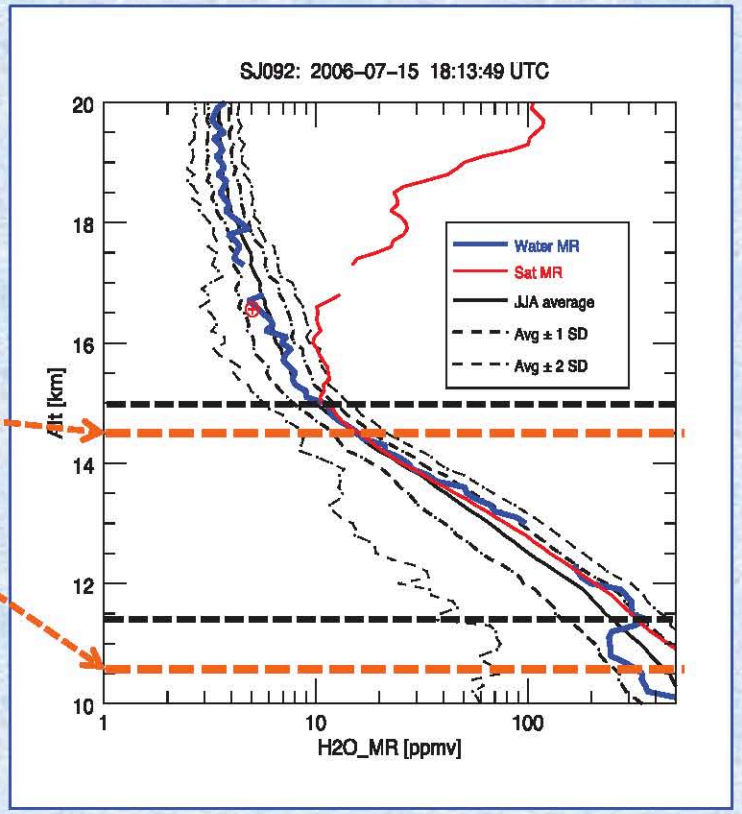
CALIOP Vertical Feature Mask comparison
15 July 2005



VFM cloud analyzed at San José 10.5 to 14.5 km



CFH saturation layer 11.4 to 15 km

- 28 VFM/CFH coincidences closer than 400 km, 2006-2011
- Preliminary finding is that CALIOP is capturing most of the layers > 1 km deep
- However, VFM is just first step – ultimate goal is to compare to ice water content

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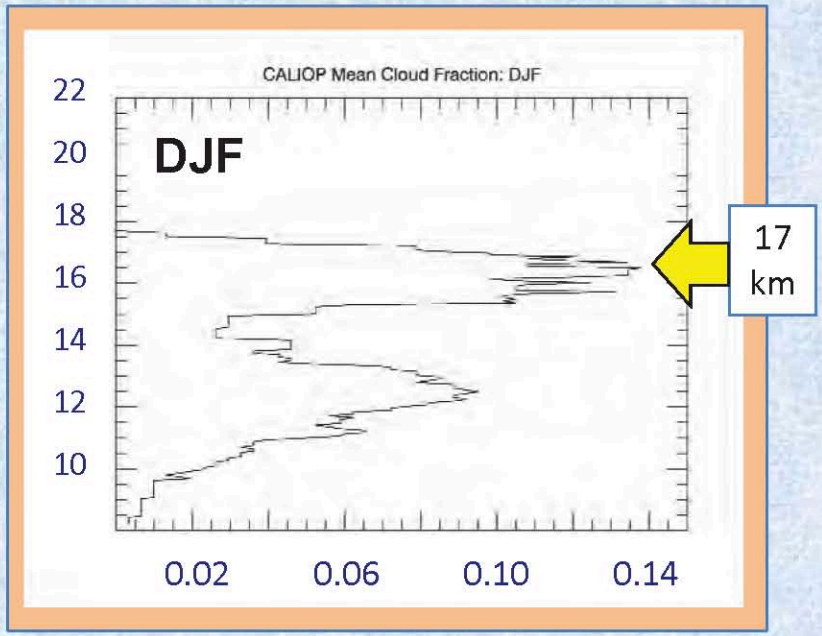
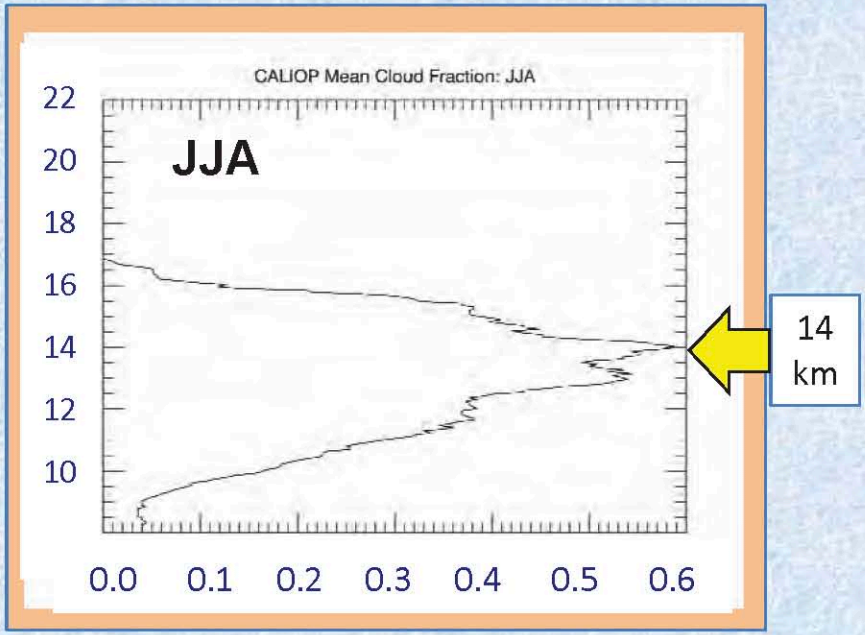
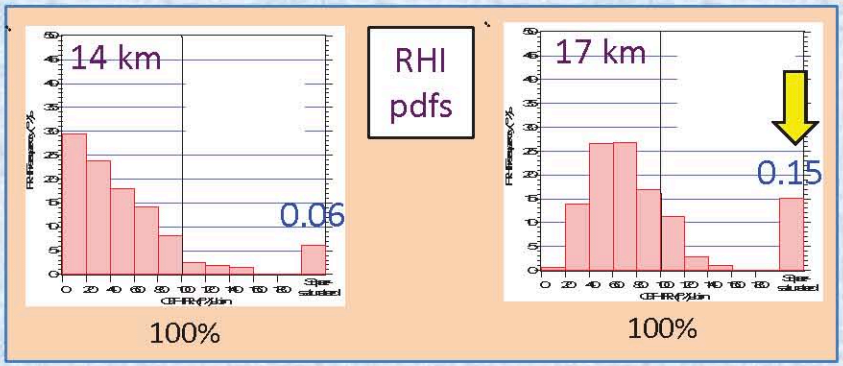
CALIOP Mean Cloud Fraction

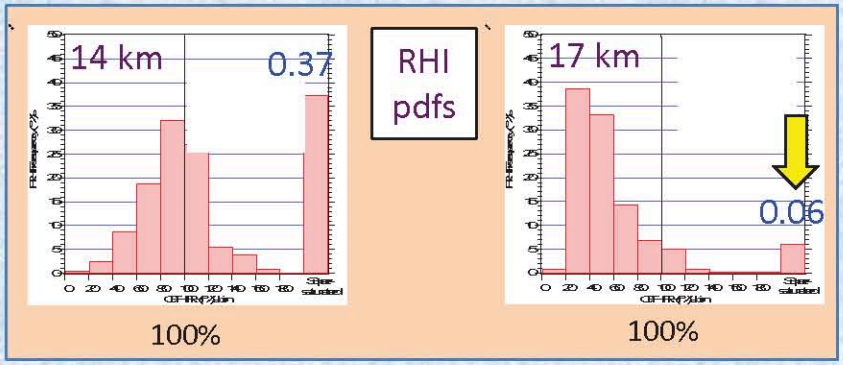
at San Jose, Costa Rica





Peak frequencies of sonde saturation





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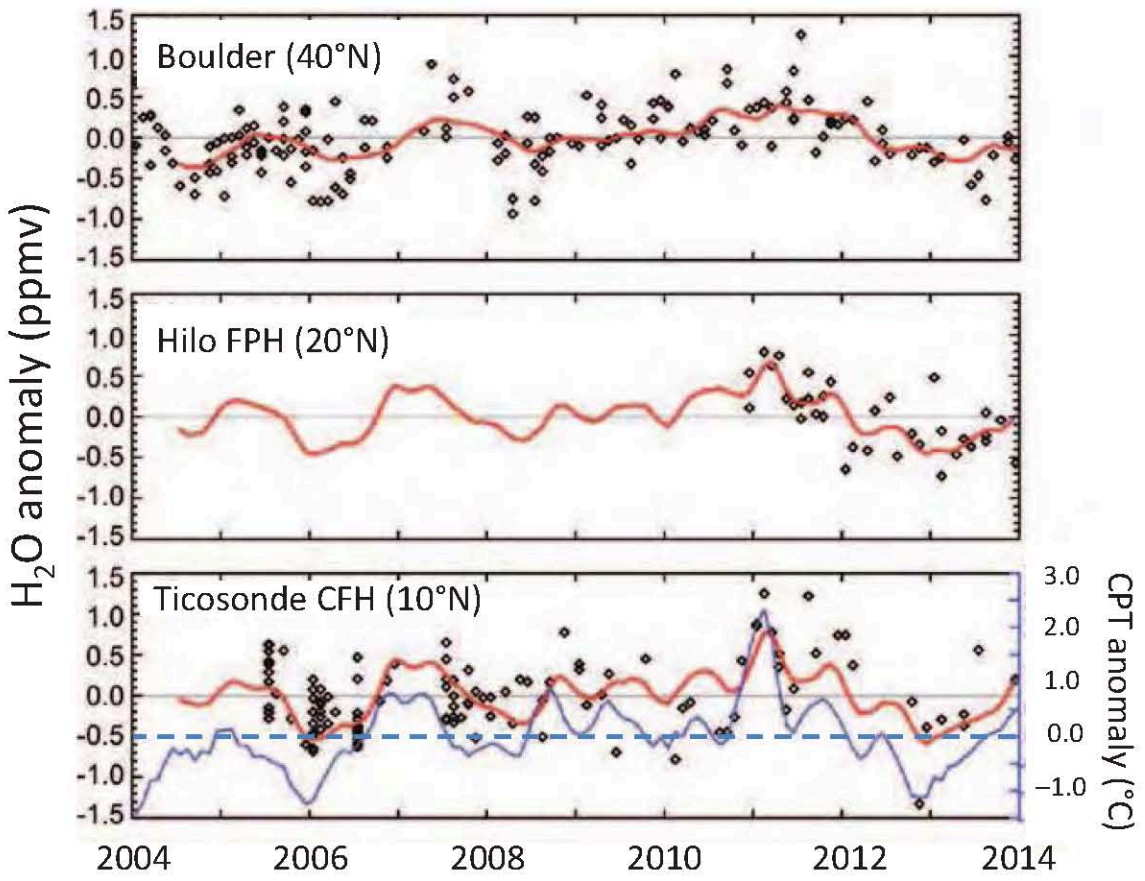
2014

Lower stratospheric water vapor

MLS, frostpoint sondes and tropical CPT

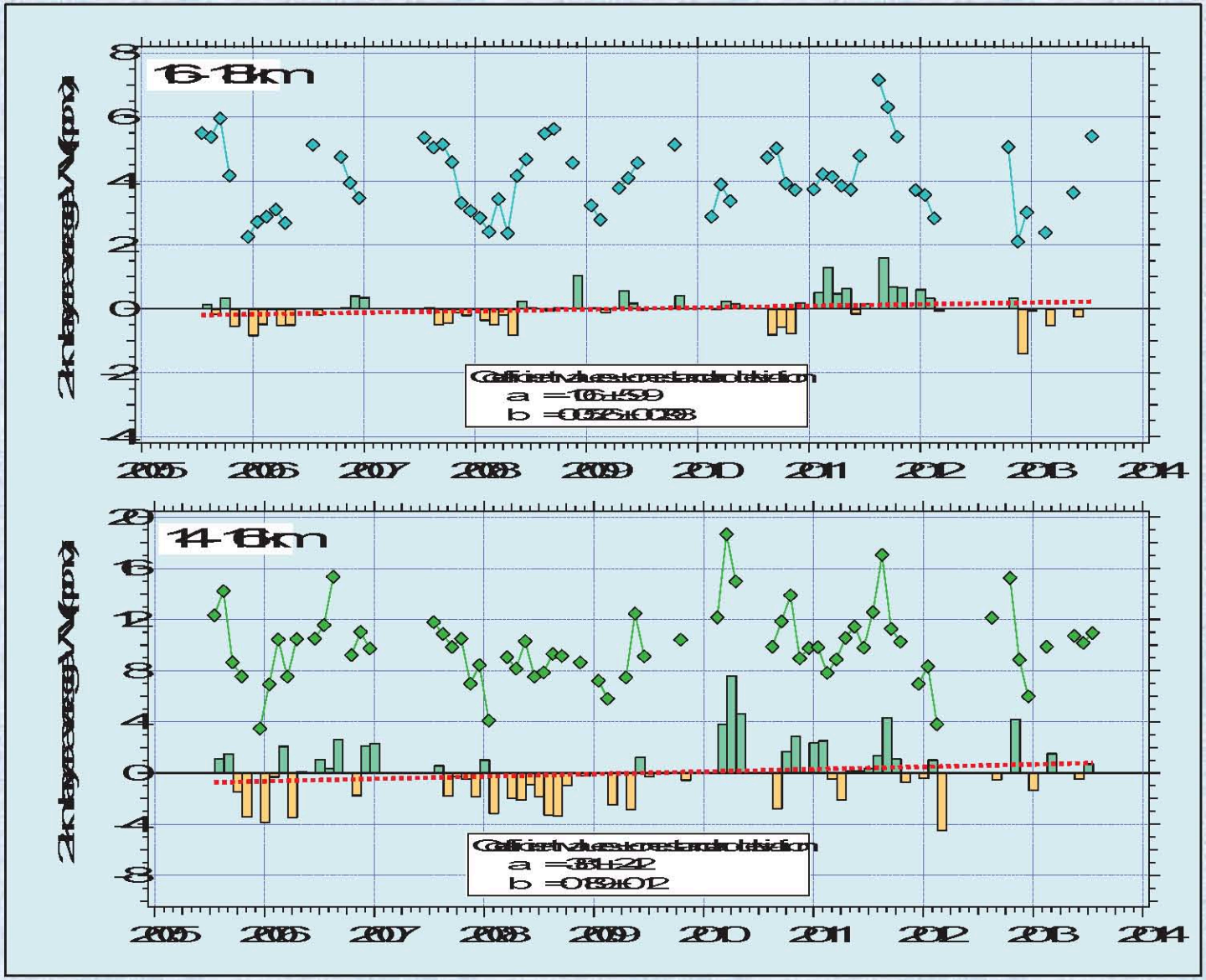


Adapted from Fig. 2.43, BAMS 2014: State of the Climate 2013

Time series calculations

- **Costa Rica CFH observations, July 2005 – July 2013**
- **Monthly time series of 2-km thick layers**
  - Linear average of 40 values at 50-m grid points
  - Centered at 3, 5, 7….. km
  - Layer average points computed only if 30 or more grid levels present
- **Multiple soundings in a month composited to a single value**
- **Monthly time means at each 1-km level derived for 8-year period**
  - Minimum sample size of 4 for each monthly level time mean
  - Exclude levels with 6 or more monthly time means missing
  - However, did allow interpolation of up to 2 consecutive missing months
  - Highest level meeting this criterion was 21 km
- **De-seasonalized anomaly time series generated**
  - Subtract long-term means for the month from each value at all levels meeting above criteria
- **Did linear fits in IGOR Pro to anomaly time series to check for trends**

Layer-average WV time series and de-seasonalized anomalies



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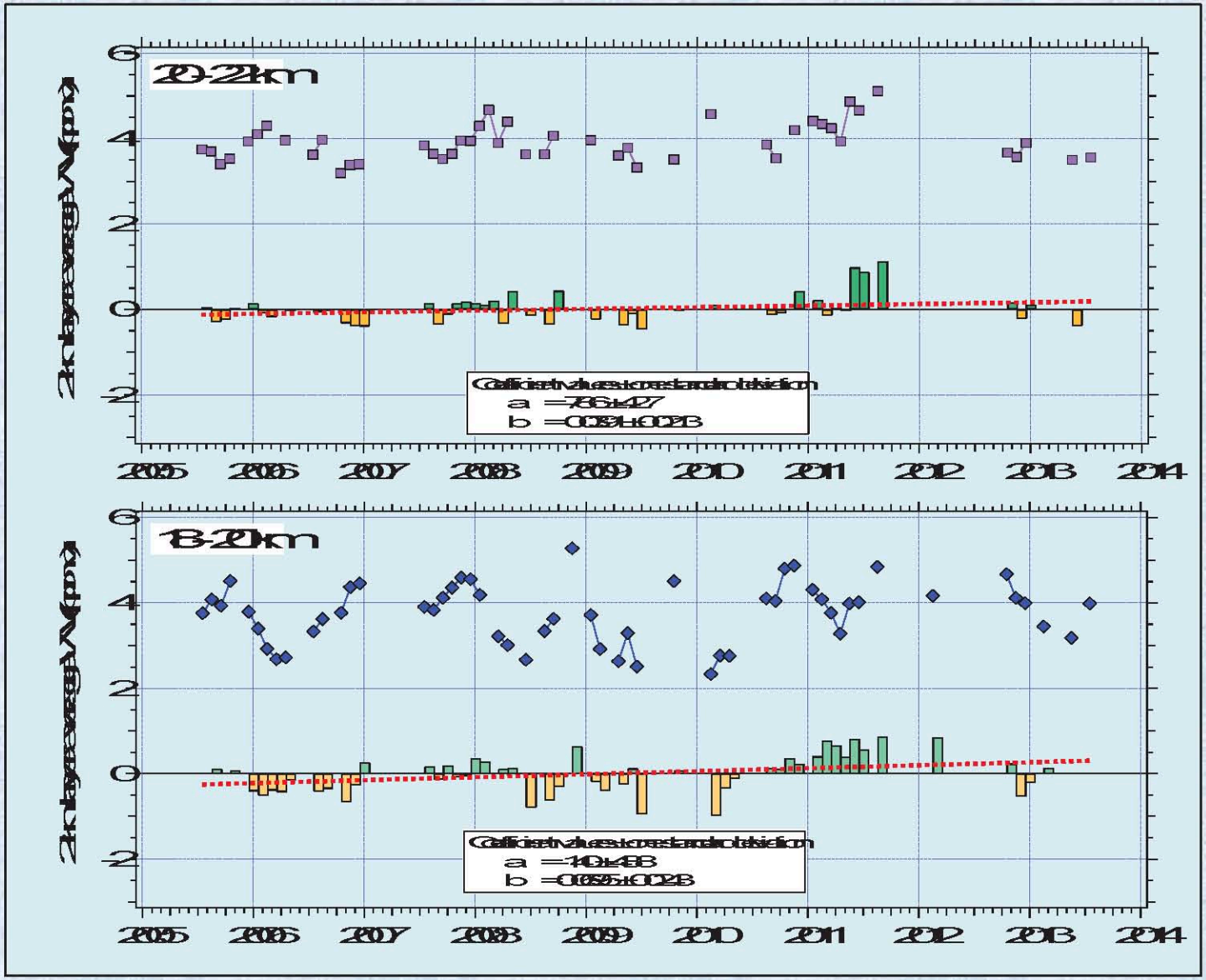
Layer-average WV time series and de-seasonalized anomalies



Summary

- Tape recorder structure at Costa Rica consistent with zonal mean, including slow uplift in early part of year in lowermost stratosphere
- Intercomparing MLS and CFH:
  - No real change from *Vömel et al.* [2007]: MLS drier than CFH in UT, wetter in LMS
  - Caveats: UT result swamped by large scatter; difference in LMS within instrumental uncertainties
- Seasonal mean CALIOP cloud fractions consistent with pattern of saturated sondes
  - Preliminary comparisons with coincident CALIOP feature mask data indicate that it can see most saturated sonde layers deeper than about 1 km are
  - However, addressing low- vs. high-density cirrus question will require information on ice water content
- Changes of WV in the tropics UT/LS:
  - Ticosonde CFH following tropical CPT values
  - Weak upward trends over nine years of program not signficant – which is not unexpected given dominance of interannual variability